AERIAL STUDIES OF THE WEST INDIAN MANATEE (*Trichechus manatus*) ON THE WEST COAST OF FLORIDA FROM 1985-1990: A COMPREHENSIVE SIX YEAR STUDY

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I. INTRODUCTION AND PROBLEM STATEMENT

The West Indian manatee, *Trichechus manatus*, is an endangered species of the order Sirenia including both manatees and dugongs. The local Florida manatee, *Trichechus manatee latirostris*, is a distinct subspecies of the Caribbean *T. manatus* (Domning and Hayek, 1986). Early studies have shown that manatee distribution and range is dependent on water temperatures but the animals are free to move from fresh to brackish or saline water. During colder months when water temperatures fall below 20° C, manatees move to warm water sources such as natural springs or man-made power plant effluent (Hartman, 1974, 1979).

Manatees are generally considered solitary animals with the only strong social bond existing between mother and calf, who remain together for up to two years or longer (Hartman, 1979). Large groups, occasionally observed throughout the year, are often mating herds. One female (cow) is pursued by several males (bulls) for up to a month while she is in estrous. Once the cow becomes receptive, she copulates successively with several bulls (Hartman, 1971, 1979). After approximately a 13-15 month gestation period, the cow gives birth to one calf (occasionally two) resulting in a three to five year breeding cycle (Moore, 1951). Lifespan and total number of calves a female can produce in her lifetime remain unknown at this time.

The Florida manatee is protected by federal, state, and even local legislation. In spite of this protection, it is still in jeopardy throughout its entire range due to a low reproductive rate, loss of habitat, and high mortality, the latter two partially associated with human activity.

In order to determine if the population level and site usage are changing long-term surveys must be conducted. Aerial surveys economically provide valuable information on habitat usage and patterns as well as relative abundance within a survey region. Due to the consistent methodology used with aerial surveys, management decisions can be based soundly on the data collected.

Numerous aerial surveys have been conducted to assess manatee populations on the West coast as well as other parts of Florida. Some population estimates based on aerial surveys determined Florida's manatee population at 1,200 with about equal numbers on the east and west coasts of the state (Weigle, 1987). Statewide synoptic surveys of the east and west coast as well as mid-state

waters to determine the Florida population counted 1465 individuals in 1991 and 1856 in 1992 (Ackerman, FDNR unpublished data).

Mote Marine Laboratory has been conducting aerial surveys to estimate manatee populations and distribution since 1985. This report presents the six years of data collected in these areas from 1985-1990. The primary objectives were to determine the relative abundance, distribution, seasonality, and habitat requirements for manatees in the bays, gulf and rivers of this study area. The continuous surveys also provide data necessary to monitor changes in level of use and to detect secondary manatee areas and possible migratory routes. Specific goals are outlined as:

Year 1. Identify if preferred areas exist.

Years 2-6. Determine variability in preferred-site usage.

Years 6-10. Monitor variability and identify habitat preference determinants.

This report presents the results and conclusions for the first two goals.

II. STUDY DESIGN

A. Field Methods

Figure 1 illustrates the study area, showing the boundaries of the northern and southern regions. The northern region extends from the northern tip of Anna Maria Island to Venice, FL and has been surveyed since 1985. The southern region, from Venice to the northern portion of Charlotte Harbor and the Myakka River has been surveyed since 1987. Each region consists of one "flight"; one "survey" of both northern and southern regions normally takes two days (and subsequently two flights) to complete.

Flights were conducted at 80-90 knots at an altitude of 150 meters (500 feet), using either a Cessna 152 or 172 high wing aircraft. Bays were surveyed starting at the north end of the survey area and flown south. The Gulf beaches and the Myakka River were typically surveyed from south to north. Occasionally, flights had to be postponed, altered or aborted (resulting in incomplete surveys) under certain conditions which include: 1) wind speed or gusts exceeded 15 mph; 2) Visual Flight Rules (VFR) were not in effect; 3) severe weather was forecast or encountered for the observation period; or 4) sighting conditions (combined water clarity and surface conditions) were too adverse.

A primary observer (with at least 25 hours of aerial survey experience

and wearing polarized sunglasses for increased visual penetration through the water) occupied the right front seat. Secondary observers occasionally occupied the rear seats. All manatee sightings were logged with appropriate notations if the primary observer did not make the initial sighting. Photographic records were made of any unique sightings or animals with scar patterns that might be recognizable in the future (these data are not covered in this report).

Once spotted, herds (also referred to as sightings and defined as one or more animals) were circled until all data could be recorded and verified. The location, number, life stage (adult or calf), and any identifiable behaviors were recorded on the standardized map sets. Manatee locations were indicated on the maps by a "T.m." with a dot (if the herd was stationary) or with a directional arrow (showing vector of movement). The number of animals in the herd was recorded next to the "T.m.", as was the initial time of the sighting and the numbers of any photos taken.

Additional data recorded for each page of the map set included: date of the survey, the beginning and end times, water clarity, surface conditions, number of adults, number of calves, and total number of manatees sighted. For the purpose of this study, calves were defined as one-half of the length (or less) of accompanying adults. Water clarity was estimated from the air throughout the study area according to the scheme in Table 1. Surface conditions were classified according to a modified Beaufort scale presented in Table 2. Incidental sightings of sea turtles *(Caretta caretta)* and bottlenose dolphins *(Tursiops truncatus)* were noted but are not discussed in this report.

Monthly air temperature averages were provided by the weather station at Mote Marine Laboratory. Daily high and low temperatures were averaged to yield a daily average. Daily measures were averaged for each month of each year to provide monthly averages between 1985 and 1990.

Each survey represents a measurement of manatee abundance for that flight only. It is assumed that many of the same manatees are recounted on subsequent flights. The total number of manatees seen for each year is a summation of sightings recorded for each individual survey for that year and does not represent an estimate of the total manatee population for the survey area. Based on low sightings during winter months during the initial surveys, these months were not surveyed as frequently during subsequent years. Since few manatees are present in the study area between December and February, resources

and effort were focused on the period between March and November when more manatees are present.

Presumably, not all manatees are sighted on a survey due to less than optimal water clarity and surface conditions occurring in the area. However, consistent application of established and broadly-accepted methodology provides a means for comparison between surveys. Thus, what is presented is a relative measure of minimum manatee abundance.

B. Analytical Methods

1. Sightings

For the present report, the total survey area was divided into two regions: north and south (Figure 1). The surveys, usually consisting of one northern and one southern flight, were assigned a letter alphabetically for each year. Manatee sighting locations are plotted on maps of the survey area (Figure 2.a-i) as a measure of instantaneous distribution. Each sighting was designated by a year, flight letter and a herd size (number of adults "+" number of calves, e.g. F3+2). The dates corresponding to the flight letters are shown in the survey summary on Table 3.

Relative abundance was shown using several methods including: total number of animals for each year, average number of manatees per survey for each year, estimated maximum population, density, and number of manatees per hour for each year.

The maximum population for the survey area previously had been determined by averaging the five highest survey counts for the northern region and the five highest for the southern region and summing these two values (Nabor and Patton, 1989). To adjust for variation in the number of surveys flown from year to year, the highest counts from 25% of the number of surveys flown were averaged in Kadel, Dukeman and Patton (1991) for the report of the 1988 aerial surveys. For the present report, the highest counts from 5% of the surveys flown were averaged to yield the closest approximation to the maximum population. Maximum populations were determined for the northern and southern regions separately using one day totals for each as well as for the entire survey area using two day totals. Density was determined by dividing the average maximum population for the entire survey area by the total area surveyed (185 km^2).

Another measure of relative abundance comes from a determination of the

number of manatees sighted per hour for each year where the survey hours were summed for each year and divided by the total number of manatees for each year. Conceptually, this measure is equivalent to catch per unit effort (Lackey, 1974).

Temporal distribution and abundance throughout the survey area were determined in several ways: total numbers of manatees and herds for each survey for each year, monthly averages for each year and for all years combined, and number of manatees per hour for each month of each year and for all years combined. In previous annual reports (MML, 1988-1990), monthly and regional indices were calculated in order to correct for months with unequal numbers of surveys or incomplete surveys. Originally described in Nabor and Patton (1989), these monthly or regional indices were based on the Total Survey Effort (T.S.E.) for each month or region. For the present report, the values for number of manatees per hour were used instead to correct for incomplete surveys.

Regional distribution was previously determined for each year as the average number of manatees sighted in each sector where the study area was randomly broken into twelve sectors. Because the "sector" designations were altered between years, the graphic representations of regional distributions presented in preceding annual reports can not be compared. To compensate, regional distribution was shown between the northern and southern regions and between individual sites (discrete areas within the study area) for each year in this report. The determination of individual site distribution was based on three calculated values: frequency, as a percent of the surveys that manatees were sighted: the average number of manatees sighted per number of surveys manatees were present; and average number of manatees per total number of surveys for each year. Location of retrieved carcasses (mortality) was also considered as a measure of regional distribution but is analyzed in more detail later. The exact location of each of the sites is shown on Figure 2.a-i and listed on Table 6. The distribution of manatees in the Gulf of Mexico also was considered separately as average number of manatees sighted per hour in the gulf.

2. Calves

Many of the same methods of determination of relative abundance, seasonal distribution and regional distribution described above were applied to calf sightings. Calf percentages were calculated for the north, south, and entire

survey region for each year. These values are compared between years and to similar studies in other areas.

3. Herds

The average herd size observed was calculated and compared between years. The percent of sightings of each size herd was also calculated and graphed to depict herd-size distributions for each year. The herd sightings for all six years were then combined and the cow-calf pairs were separated from other adults to identify the proportion of these pair bonds in herds of greater than one. The number of these pairs was determined by assigning one adult from a herd as "mother cow" for each calf counted. The rare sightings with one adult and two calves (n=2) were adjusted for, but otherwise there was assumed to be no twinning or fostering. The proportions of the cow-calf pairs within each size herd were then graphed adjacent to percentage of herd size distribution for all six years.

Occasionally, medium to large groups of manatees could be identified as mating herds. For the occasions when groups engaged in mating activity were recorded, the number of animals and number of herds were summed for each month, providing an analysis of seasonality.

4. Mortalitv

Manatee mortality data for 1981-1990 were provided by the Florida Marine Research Institute, St. Petersburg, Florida. Deaths were categorized by cause and graphed,

III. RESULTS AND DISCUSSION

A. SIGHTINGS

1. Relative Abundance

Table 3 shows the dates and numbers of manatees sighted for each aerial survey conducted between 1985-1990 for both the northern and southern regions. Throughout the course of the six year study, various flights were aborted or altered from the standard procedure due to extenuating circumstances such as observer illness, foul weather, etc. Each annual report noted these alterations (Patton, 1986; Patton, Kreckman and Sprinkel, 1987; Nabor and Patton, 1988; Morgan and Patton, 1990; Kadel, Dukeman and Patton, 1991; Kadel, Morgan and Patton, 1991). During the 113 surveys conducted over six years, 4638 manatees

and 2219 herds were sighted. The highest count of manatees during one survey, 117, was observed during July 1989. The overall density of manatees within the survey area based on the average maximum population is 0.58 manatees/km^2.

The total numbers of manatees and herds counted for each year are shown in Table 4 with the number of surveys conducted and the average number of manatees seen per survey for each year. The 1988 surveys showed the highest total (1280 animals) while 1989 showed the highest average (73.6 manatees per survey).

The average number of manatees sighted per hour was determined for each year and is shown in Figure 3. The concentration of manatees is much greater in the southern region. The concentration of manatees in the Gulf, for north and south regions combined, is shown in Figure 4. Due to the small number of Gulf sightings, no distinction was made between the north and south regions. The concentrations remain relatively constant from year to year, although higher values were achieved in 1989 in the overall survey area and in 1987 in the gulf.

Related to survey average is the maximum population shown in Table 5. The maximum population of manatees for the survey area averaged over the entire study period is 43.5 (s=8.7) in the north, 81.4 (s=ll.O) in the south, and 107.2 (s=15.3) for the entire area using complete, two-day surveys. Estimates slowly increased from 1985 until 1989 showed the highest population for any single year for the north (54), south (92), and total area (117) but dropped in 1990 below the average. Since fewer surveys were conducted in 1990, it is difficult to determine the significance of data from that year. A continuation of the surveys is necessary to determine any trends.

2. Temporal Distribution

Seasonal distribution of manatees can be shown in a number of fashions. Previously, the number of manatees sighted per survey were graphed for each year. In a comparison of these graphs (in each year's annual report) coupled with a graph of monthly averages (Figures 5a and 5b), some loose common trends can be seen from year to year. Peaks are observed in most years in mid to late April or early May following the low numbers during the winter months (January, February, sometimes March), the exception being 1989. Years with mild winters show higher numbers in January-March. A second peak is often observed in late May/early June. During the summer and early fall months, sightings are highly variable between years (i.e. 1988, 1989 and 1990 show peaks for July while 1987

shows a low). All years show a peak at some point during this period; July in 1988, 1989 and 1990, September in 1985 and 1987, October in 1986 and 1988. This variability suggests a high degree of movement through the survey area and beyond. A late fall peak is observed in many years in November and early December. It is possible that during the summer months, manatees disperse further offshore or far inland into residential canals and backwaters not surveyed leading to the low August counts. The late fall increase observed would then result if the animals left those areas and moved to more centralized locations (such as the bays and sounds) as they prepared to migrate.

Figure 5b combines monthly averages of number of manatees sighted for all years for the months most consistently surveyed (between March and November). The graph approaches a normal distribution but it could be bimodal. Small peaks were observed in June-July, September and April. Decreased sightings occurred in August as well as the cooler months of January, February and December (not depicted) and to a lesser extent in March and November.

Figure 6a shows the monthly average number of manatees sighted per hour for all months for each year to adjust for unequal surveys and those months surveyed less frequently. As with surveys in other areas, sightings vary greatly from month to month for each year. A peak in one month is often followed by a sharp decrease in the following month, yet a few trends can be seen, similar to those shown in Figure 5a. A spring or early summer peak occurs during April in 1988 and 1990 and May in 1986, 1987, and 1989. A second peak is observed in the late spring-early summer (June of 1985 and 1990 and July of 1988 and 1989). Mid-late summer shows generally low levels of manatees for all years except 1987 which shows a small increase. A third peak is observed during the fall (October of 1986 and 1988 and November of 1987, 1989, and 1990). These trends, similar to those shown in Figure 5a, provide a more accurate account of monthly manatee distribution since they correct for unequal amounts of effort.

Figure 6b combines the average number of manatees sighted per hour for each month for all years. These values show highest rate of manatee sightings (and therefore highest numbers of manatees) in June and October (7.7/hour), decreased numbers in August (5.4) and lowest in January (2.3/hour). The decrease-increase cycle between July and September is similar to the variability observed in the other averages, further indicating increased movement within and/or outside the survey area.

Monthly air temperatures, which are related to water temperatures and affect manatee movements, are shown in Figure 7. Generally, 1986 and 1987 had cooler temperatures throughout the year while 1989 and 1990 were warmer. Temperatures between May and September are similar for all years. During the fall and winter months, there was more disparity from year to year with varying degrees of cold winters. Analysis of the graph reveals months of some years which are warm or cold relative to the other years. These temperature highs and lows can be compared to manatee sighting highs and lows, offering some explanation of monthly manatee population levels. Higher temperatures and corresponding relatively high numbers of manatees were observed in January 1989, February 1989 and 1990, March 1985, April 1990, October 1990, November 1989 and 1990, and December 1986. February 1988 had low temperatures and also low manatee counts as did September 1986, October 1987, November 1986, and December 1989. Although temperature highs and lows were present in other months which did not result in similar levels of manatees, the late fall and early winter months, when manatee distribution is most greatly dependent on temperature, do show a fairly consistent temperature-population level relationship.

Figure 8, which depicts the average number of manatees sighted per hour in the Gulf, contrasts to numbers of manatees sighted through the entire survey area in its random nature. Gulf sightings were spread out over the year. Many manatees were sighted between mid-spring and early fall with most sightings during the summer and early fall with October, August and December being the highest. Relatively few manatees were sighted in the Gulf of Mexico for each year; therefore, any one year or one survey with a randomly large number of manatees would skew the graph. Further studies and additional gulf sightings need to be accumulated before strong conclusions can be drawn.

3. Regional Distribution

Figure 6b also shows the regional distribution in the north and south regions separately as number of manatees sighted per hour per month. As with other measures of population and distribution in this study, the south region shows a much higher concentration of manatees than the north. In the south, the concentration rapidly increased through the winter (January-March), peaked during the spring months (April-June), dropped during the summer to an August low, while concentrations in the north slowly increased through the winter and spring, increased again in May, remained constant through the summer and peaked

during early fall months (September-October).

It appears that the animals prefer to use the southern region earlier in the year and the northern region later in the year. This might indicate that manatees in southern winter areas (i.e. Ft. Myers) disperse to the north more quickly than animals in northern winter areas (i.e. Tampa power plants) disperse to the south as a result of warming southern waters. Another possibility is that animals wintering south of the study area first enter the southern region then slowly travel to the northern region before returning to either northern or southern winter grounds. A study of movements of radio-tagged manatees (Lefebvre and Frohlich, 1986) indicates that individual animals tagged during January (winter) in Ft. Myers were sighted in Sarasota Bay in March, Manatee River in April, and Little Sarasota Bay in October. Another animal tagged in Ft. Myers was resighted in Lemon Bay in March and Little Manatee river in October while a third was resighted in the Myakka River in June and again near Salt Creek in Nokomis also in June. Other Ft. Myers animals were sighted in Turtle Bay, Charlotte Harbor and the Myakka River in March-June, following the suggested trends. A third possibility is that the shifts may simply be a result of random dispersal.

Manatee sightings for each survey, another measure of regional distribution, are mapped in Figures 2.a-i. These sightings reflect a "snap shot" view of manatee distribution and abundance. Areas of concentrated manatee use can be identified from these maps as well as from public reports. Regular and recurring use is observed in some areas while other locations have shown changes in use. Table 6 lists many of these areas with measures of abundance for each year. The numbers in parenthesis refer to calf abundances at the sites. Based on these abundances, some trends are seen.

At the commencement of the aerial survey project, the southeast corner of Anna Maria Sound adjacent to Manatee Ave Bridge (Site 1) appeared to be an area of heavy manatee use. In 1987, a dormant marina reopened and boat activity in the area increased. The immediate effect was a 58% decrease in manatee sightings. Nabor and Patton (1989) suggest a decrease in manatee utilization of the area as a negative result of increased human activity. Since that publication, manatee use increased close to 1985 levels in 1989 and then decreased again in 1990. A continued analysis of usage needs to be maintained in order to reach any definite conclusions correlating manatee and human activity.

Longboat Pass (Site 2) has shown decreased then increased aerial sightings. Telemetry data (from FDNR) may reveal whether this area is important as a migratory route as it allows access between the gulf and the bays.

Bowlees Creek (Site 3) is another area with variable manatee usage. Although Table 6 does not show a high concentration of manatees, numerous unsolicited public reports suggest its importance. Because this area is adjacent to active runways of the Sarasota/Bradenton Regional Airport, it is difficult to thoroughly survey this area. At some times, it is not possible to survey the area at all. Therefore, increased and consistent survey attempts must be made to adequately document and confirm its importance as an area of high manatee usage.

Buttonwood Harbor (Site 4) has shown a steady increase in manatee sightings while the Hyatt Boat Basin at the northeast corner of Ringling Bridge (Site 5) has shown a decrease. Although both sites have boat activity, the smaller area at the Hyatt may mean less room for manatees to evade traffic. Also, stormwater inputs to the basin which may have attracted manatees to the area could have decreased during recent drought years.

Pansy Bayou (Site 6), like Buttonwood Harbor, has exhibited an increase in manatee use. Extensive grass beds, areas of deep water and the relative isolation from boat traffic provides a favorable habitat for the animals. Much of the other nearby waters shown on Figure 2c also show high manatee utilization. Alternately, the former Midnight Pass region (Site 8) has shown a decrease in manatee abundance. The pass closed before the surveys began. Changes that have ensued, such as decreased water circulation may have decreased the suitability of the habitat.

In the southern region, Forked Creek (Site 9) and Lemon Bay (as shown on Figure 2f) have had consistently high manatee sightings. Also in the south, the Turtle Bay area (Site 10) has exhibited an increase in sightings while the Big Slough area (Site 11) decreased, but then slightly increased. These trends indicate that although preferred sites exist and for the most part hold up from year to year, long-term changes in usage do occur. Continued monitoring of these sites will determine if these changes and trends are permanent or temporary and may shed more light on causal relationships.

B. CALVES

1. Relative Abundance

The percentage of calves observed for each year of the survey is graphed in Figure 9. Percentages in the north and south are also displayed. Maximum percentages observed were 11.7% for the north, 15.3% for the south and 12.9% for the total area, all recorded in 1990 although 12.4% total area calf sightings occurred in both 1987 and 1988. Minimums in the north were 6.7% in 1986, 10.1% in the south, and 9.8% in the total area, both in 1989. The average calf percentage for all surveys was 9% in the north, 13.1% in the south, and 11.9% for the entire area (s=1.7, 1.9, and 1.2 respectively). The southern region had higher percentages in all six years indicating it may be consistently important as a nursery area. The calf percentages were fairly constant from year to year except for the 1989 lows. A Florida Power and Light (FPL) 1989 study of winter power plants did not show this decrease (Reynolds, 1991). Determination of "calves" is somewhat subjective based on an approximation of "half the size of an accompanying adult" as also noted in Reynolds et al (1991); therefore, observer differences may have influenced the 1989 decrease.

Other studies (Reynolds, 1991; Reynolds et al., 1991) have shown a general decrease in calf percentages during winter surveys throughout the state and year-round surveys in Tampa Bay over the last several years although this trend is not seen in the MML study area. The six year MML survey average ($\bar{x}$=11.9) is higher than both Reynolds' winter surveys since 1984 (6.8%-10.5%) and Tampa Bay surveys from November 1987-December 1990 (6.4%-11.0%, x=8.4%). For the MML study area, the percentage of calves is not changing dramatically from year to year. To adjust for observer differences and confirm or refute any theories of changes in calf percentages, population monitoring should continue.

2. Regional Distribution

Table 6, which shows manatee distribution in several sites, also contains information specific for calves. Similar to distribution of adults, many sites showed varying levels of calf use. Frequency of calves in the southeast corner of Anna Maria Sound (Site 1) decreased in 1986, before the marina reopened and gradually increased through 1989 although none were sighted in 1990. Alternatively, Longboat Pass (Site 2), previously without calves, had relatively high numbers in 1990. Buttonwood Harbor (Site 4) and the Hyatt Boat Basin (Site 5) also had variable calf frequencies. Although Pansy Bayou (Site 6) had no

calf sightings in 1986, other years had high numbers and show a gradual increase indicating it may be important as a nursery. Forked Creek (Site 9) and Turtle Bay (Site 10) also usually have high numbers of calves, indicating the possible value as a nursery area, but all three areas also have high numbers of adult manatees as well.

C. HERDS

1. Relative Abundance

The average number of herds per flight and average herd size for each year are shown in Table 7. The highest average number of herds per survey were observed in 1990 and 1988 (31.5 and 29.0 respectively). These values parallel the average number of manatees per flight shown in Table 4. The lower 1990 manatee average and higher herd average compared to 1988 is due to the smaller average herd size in 1990.

The highest average herd size of 2.3 occurred in 1985 while 1990 had the lowest of 1.9. The average herd size for all six years ($\bar{x}=2.1$) is similar to that of the first two years ($\bar{x}=2.15$); therefore, average herd sizes between north and south regions are comparable. The low standard deviation for the six years ($s=0.11$) shows the consistency of the herd size of 2.1.

The herd size distribution percentages in Figure 10 are consistent with the average herd size data. Most years exhibit very similar distributions as shown by the high degree of overlap of the graphs. Slight differences were observed in 1985 which had fewer herds of two but more herds of 4,5,7, and 13 animals resulting in the high average herd size. A large proportion of herds of 6 and 8 were seen in 1986. More single animal sightings were counted in 1990 and fewer herds of 3 or more thus leading to the low average herd size.

The proportions of cow-calf pairs for all six years in Figure 11 demonstrate that these relationships constitute a large portion of herds greater than one. Cow-calf pairs are responsible for almost half of the herds of two animals. As herd size increases, the effect of cow-calf pairs becomes less significant, but is apparent in herds of all sizes. Therefore, many of the herds of two or more animals, which may suggest the existence of social bonds, are merely the result of calf dependence.

2. Temporal Distribution

The monthly distribution of mating herds is shown in Figure 12. Few

mating herds were sighted in December, January, or February, but there were also fewer sightings of any animals during those months. Most mating herds were sighted in August, September, and June. Most manatees were sighted in September and June as well. Between these months, there were relatively few mating animals and very few herds leading to a high average size of the mating herd (i.e., $\bar{x}=11.5$ in July). According to Hartman (1979), manatees mate throughout the year; therefore, any seasonality of mating herds within the study area would be expected to be correlated to seasonality of the region's manatee population, as it does. As with the definition of calves, there is some variation in observers' determination of mating herds. Continued studies and a larger data base are necessary to reduce the effect of observer variation and establish or dismiss the existence of a seasonality of mating herds.

D. MORTALITY

Manatee mortality in Sarasota County for the six years of this report and the four previous years are shown in Figure 13. A somewhat linear increase in overall total number of deaths has been seen. Levels of perinatal calf mortalities have been irregular over the study period. There does not appear to be a correlation between calf mortalities and calf sighting percentages. For example, 1986 with a low calf percentage (6.7%) had a high number of calf mortalities (3) while 1987 and 1990 respectively had 12.4% and 12.9% calf percentages, 0 and 4 calf mortalities were recorded.

Human activities, such as boat and barge operation, have had a strong detrimental effect on manatees in the study area and throughout the state. Prior to 1986, zero manatee mortalities could be attributed boat collisions. Between 1987 and 1990, two have occurred each year. This represents 38% of the manatee deaths between 1987 and 1990 directly attributable to motorboats. Also, propeller scars visible on the backs of many manatees indicate a high rate of injury. With recreational and commercial boat use increasing on the waters of Sarasota and Florida, the manatees are at continuously increasing risk. Although cause of death can not be directly determined in some cases, there are other human activities which put manatees at increasing risk. Pollution, dredging, and development decrease the quality and quantity of suitable manatee habitat for feeding and nursery grounds, putting the manatee at further risk.

Management recommendations, implementation and enforcement (beginning with

the recently enacted speed zone restrictions) and continued study and monitoring are necessary to maintain the manatee populations in Sarasota and Florida waters.

IV. SUMMARY

The different indicators of manatee abundance were ranked for each year from highest to lowest to identify annual trends (Table 8). The average value from all six years for each indicator is also displayed. In 1989, highest values were observed for total number of manatees, manatees per hour in the north, south and total survey area, average number of manatees per flight, average number of herds per flight, and maximum population as well as second highest mortality although calf percentage and herd size was among the lowest of all years. Both years in which only the north region was surveyed displayed some of the lowest values for all variables except herd size which was highest of all six years in 1985. This could be the result of observer experience or lower manatee populations in the north. After the south region was added, 1987 showed low values for many of the indicators except calf percentage and herd size. Additionally, some values decreased in 1990, such as maximum population, possibly as a result of reduced numbers of surveys.

The average number of manatees sighted per hour was higher in the south ($\bar{x}$=10.6, s=2.4) than either the north ($\bar{x}$=3.8, s=1.1) or total survey area ($\bar{x}$=6.2, s=2.4) as are most regional parameters. The maximum population ($\bar{x}$=107, s=25.3) has been fairly consistent until 1990 when decreased surveys may have decreased the average and increased the standard deviation. Calf percentages ($\bar{x}$=11.9% s=1.2) were higher than those reported in similar studies of other areas, Pansy Bayou, Forked Creek, and Turtle Bay are examples of areas with generally high or increasing counts of calves as well as adults. These habitats seem to provide favorable conditions and may have high nursery value. Mortality, especially due to human related causes, has increased and must be checked if manatee populations are to recover and flourish.

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APPENDIX A. TABLES

Table 1. Water clarity scale (m=meter)

Scale		Visibility Through Water
EXCELLENT	=	Greater than 3m.
GOOD	=	2-3m.
FAIR	=	3/4-2m.
POOR	=	1/4-3/4m.
BAD	=	Less than 1/4m.

Table 2. Surface conditions scale.

Scale	Effects observed at sea
0	Mirror-like seas.
1	Ripples with appearance of scales.
2	Small wavelets; crests begin to break; scattered whitecaps.
3	Large wavelets, crests begin to break; scattered whitecaps.
4	Moderate waves, taking a longer form; many whitecaps; some spray.

(Adapted from the Beaufort Scale, which is not suited for nearshore use).

Table 3. Summary of surveys. (MC=Mantee Count for north & south.)
(TOT=Total count for entire area.)

	1985		1986		1987			1988			1989			1990		
LTR	DATE	TOT	DATE	TOT	DATE	MC	TOT	DATE	MC	TOT	DATE	MC	TOT	DATE	MC	TOT
A-N	1/7	1	3/12	0	1/29	1	3	1/15	0	4	1/10	3	53	2/8	6	61
-S					1/30	2		1/16	4		1/12	50		2/13	55	
B-N	1/22	0	3/24	2	2/4	1	2	2/22	0	5	1/30	7	99	3/27	8	44
-S					2/12	1		2/18	5		2/1	92		4/9	36	
C-N	2/9	0	4/7	4	2/21	1	1	3/31	15	54	3/13	0	63	4/19	9	65
-S					2/26	0		3/31	39		3/14	63		4/24	56	
D-N	2/18	0	4/24	12	3/11	1	18	4/27	19	99	3/27	13	103	5/18	17	34
-S					3/12	17		4/29	80		4/3	90		5/25	17	
E-N	3/3	4	5/5	19	3/23	4	60	5/10	6	64	4/19	10	62	6/11	30	71
-S					3/25	56		5/11	58		4/18	52		6/14	41	
F-N	3/20	4	5/22	9	4/6	0	53	5/23	21	69	5/4	23	79	7/17	15	77
-S					4/8	53		5/26	48		5/5	56		7/19	62	
G-N	4/1	2	6/2	14	4/20	5	68	6/2	9	84	5/15	26	94	8/23	36	58
-S					4/22	63		6/3	75		5/22	68		8/28	22	
H-N	4/17	11	6/16	6	5/16	13	54	6/16	10	75			41	9/19	9	43
-S					5/17	41		6/17	65		5/31	41		9/26	34	
I-N	4/29	7	7/7	20	5/27	24	108	6/27	11	42	6/12	38	95	10/23	32	50
-S					5/28	84		6/28	31		6/14	57		10/30	18	
J-N	5/13	20	7/14	8	6/9	27	89	7/11	8	62	7/1	54	117	11/6	39	78
-S					6/11	62		7/13	54		7/19	63		11/8	39	
K-N	5/28	19	7/26	18	6/23	13	86	7/25	10	86	8/22	39	97			
-S					6/24	73		7/26	76		8/23	58				
L-N	6/10	24	8/8	20	7/9	18	44	8/11	13	38	9/14	35	78			
-S					7/13	26		8/17	25		9/6	43				
M-N	6/24	14	8/22	8	7/22	25	40	8/25	16	16	10/2	43	57			
-S					7/24	15					10/3	14				
N-N	7/9	18	9/4	17	8/5	14	35	9/20	36	69	10/18	35	61			
-S					8/7	21		9/1	33		10/19	26				
O-N	8/6	10	9/18	9	8/19	18	59	9/28	28	103	11/1	34	89			
-S					8/21	41		9/27	75		11/2	55				
P-N	8/20	22	10/2	25	9/9	32	75			78	11/20	27	51			
-S					9/11	43		10/4	78		11/21	24				
Q-N	9/6	26	11/11	18	9/28	24	59	10/11	49	113	12/7	2	12			
-S					10/3	35		10/12	64		12/11	10				
R-N	9/23	26	11/26	11	10/20	27	40	10/24	38	109						
-S					10/24	13		10/25	71							
S-N	10/17	1	12/10	33	11/16	12	27	11/17	41	41						
-S					11/24	15										
T-N	10/14	17	12/26	12	12/10	8	26	12/6	14	47						
-S					12/11	18		12/7	33							
U-N	11/12	30						12/20	5	22						
-S								12/21	17							
V-N	11/25	4														
-S																
W-N	12/4	32														
-S																
X-N	12/10	21														
-S																
Y-N	12/23	1														

Table 4. **Annual totals of surveys, herds, manatees, and average, 1985-1990. (x=average and s=standard deviation for** 1987-1990 **only)**

Year	Surveys	Herds	Manatees	Avg. No. Manatees/Survey
1985	25	138	314	12.56
1986	20	136	265	13.25
1987	20	435	947	47.35
1988	21	608	1280	60.95
1989	17	587	1251	73.59
1990	10	315	581	58.10
Totals	**113**	2219	4638	
$\bar{X}$=	17.0	486.3	1014.8	60.0
s=	4.3	119.3	282.4	9.3

Table 5. **Maximum counts for 5% of each year's flights,** 1985-1990. (*= 1987-1990 **only)**

	North	South	Total
1985	32		
1986	33		
1987	32	84	108
1988	49	80	113
1989	54	92	117
1990	39	62	78
$\bar{X}$=	43.5	81.4*	107.2*
s=	8.7	11.0*	15.3*

Table 6. Distribution of manatees in specific sites, 1985-1990,

***NOTE: Numbers in parenthesis refer to calf distributions.**

KEY: 1.= % of surveys manatees were sighted (frequency).
2.=Avg. number of manatees/survey for surveys with sightings,
3.=Avg. number of manatees/survey for all flights for the year.
4.=Number of mortalities (1989-1990 only).

Site #:		1	2	3	4	5	6	7	8	9	10	11
Site Location:		SE Corner Anna Maria Sound	Long-boat Pass	Bowles Creek	Button-wood Harbor	Hyatt Boat Basin	Pansy Bayou	Phillippi Creek	Midnight Pass	Forked Creek	Turtle Bay	Big Slough
Year:												
1985	1.	64 (12)	12	4	16 (4)	8 (8)	32 (8)	8 (4)	16 (4)			
	2.	2.5 (1)	1.7	2	1 (1)	5.5 (1)	2 (1)	1.5 (1)	6.25 (1)			
	3.	1.6(.12)	.2	.1	.2(.04)	.4(.08)	.6(.08)	.1(.04)	1(.04)			
1986	1.	60 (5)	5	10	0	5	20	0	35			
	2.	3.1 (1)	2	4	0	3	1.25	0	2.4			
	3.	1.8(.05)	.1	.4	0	1.5	.3	0	.85			
1987	1.	25 (10)	15	0	25 (15)	20	40 (25)	10	20	55 (35)	70 (40)	40 (5)
	2.	2.0 (1)	1.3	0	2.6 (1)	1.5	3.5(1.2)	1.5	5.7	4.2 (1)	15.7(4.9)	3 (1)
	3.	0.5 (.1)	.2	0	.9(.15)	.3	1.4(.25)	.15	.2	2.3(.35)	10.2 (2)	1.2(.05)
1988	1.	20 (10)	10	0	30 (5)	5	40 (15)	0	5 (5)	30 (15)	71 (50)	29
	2.	4.2(1.5)	2	0	1.7 (1)	1	3.5 (1)	0	5 (1)	2.7(1.3)	11.7 (2)	.35
	3.	.8 (.5)	.2	0	.35(.05)	.1	1.4(.15)	0	.24(.05)	.8(.15)	8.4 (1)	.28
1989	1.	65 (12)	0	**18**	**35 (18)**	**12** (10)	53 (29)	0	12	47 (12)	76 (59)	24
	2.	2.2 (1)	0	1	4.8 (1)	3 (1)	3.9 (1)	0	1.5	3.25 (.1)	15.9(2.3)	1
	3.	1.4(.12)	0	.2	1.7(.18)	.35 (.1)	2.1(.29)	0	.14	1.5 (.2)	12.2(1.3)	.22
	4.	0	0	0	0	0	0	1	0	0	0	0
1990	1.	30	50(30)	0	60 (30)	10 (10)	50 (40)	0	10 (10)	40 (20)	100 (50)	33
	2.	1	2 (1)	0	2.3 (1)	1 (1)	3.2(1.2)	0	2 (1)	2.7 (1)	8.8(1.6)	3.7
	3.	.3	1(.3)	0	1.4 (.3)	.1 (.1)	1.6 (.4)	0	.2 (.1)	1.1 (.2)	8.8 (.8)	1.1
	4.	0	0	0	0	0	0	2	0	1 (1)	0	0

Table 7. Average number of herds per survey and average herd size. (* Only north portion of surveys in 1985 and 1986)

Year	Avg. no. herds/survey	Avg. herd size
1985*	5.5	2.3
1986*	6.8	2.0
1987	21.8	2.2
1988	29.0	2.1
1989	17.8	2.1
1990	31.5	1.9
x=		2.1
s=		0.11

Table 8. Summary of sightings: annual rank and six year averages, 1985-1990. **[Avg.= average; #= number; srv= survey; Max. Pop.= Maximum Population;** *=1987-1990 **only. Ranks for each category range from 1 (highest) to 6 (lowest). If two had identical value of any indicator, the next two rank orders were averaged and assigned to both years.]**

	Year	Manatees/hour North	Manatees/hour South	Manatees/hour Total	*Avg. No. Herds/srv	*Avg. No. Manatees/srv	Max. Pop.	Calf %	Mortality	Avg. Herd Size
Rank:	1985	5	-	4	6	6	4	4	6	1
	1986	6	-	6	5	5	6	5	5	5
	1987	3	4	5	4	4	5	2	4	2
	1988	2	2	3	3	2	2	2	1	3.5
	1989	1	1	1	1	1	1	3	2.5	3.5
	1990	4	3	2	2	3	3	1	2.5	6
Average		3.8	10.6	6.2	28.6	60.0	107.2	11.9	4.3	2.1

APPENDIX B. FIGURES

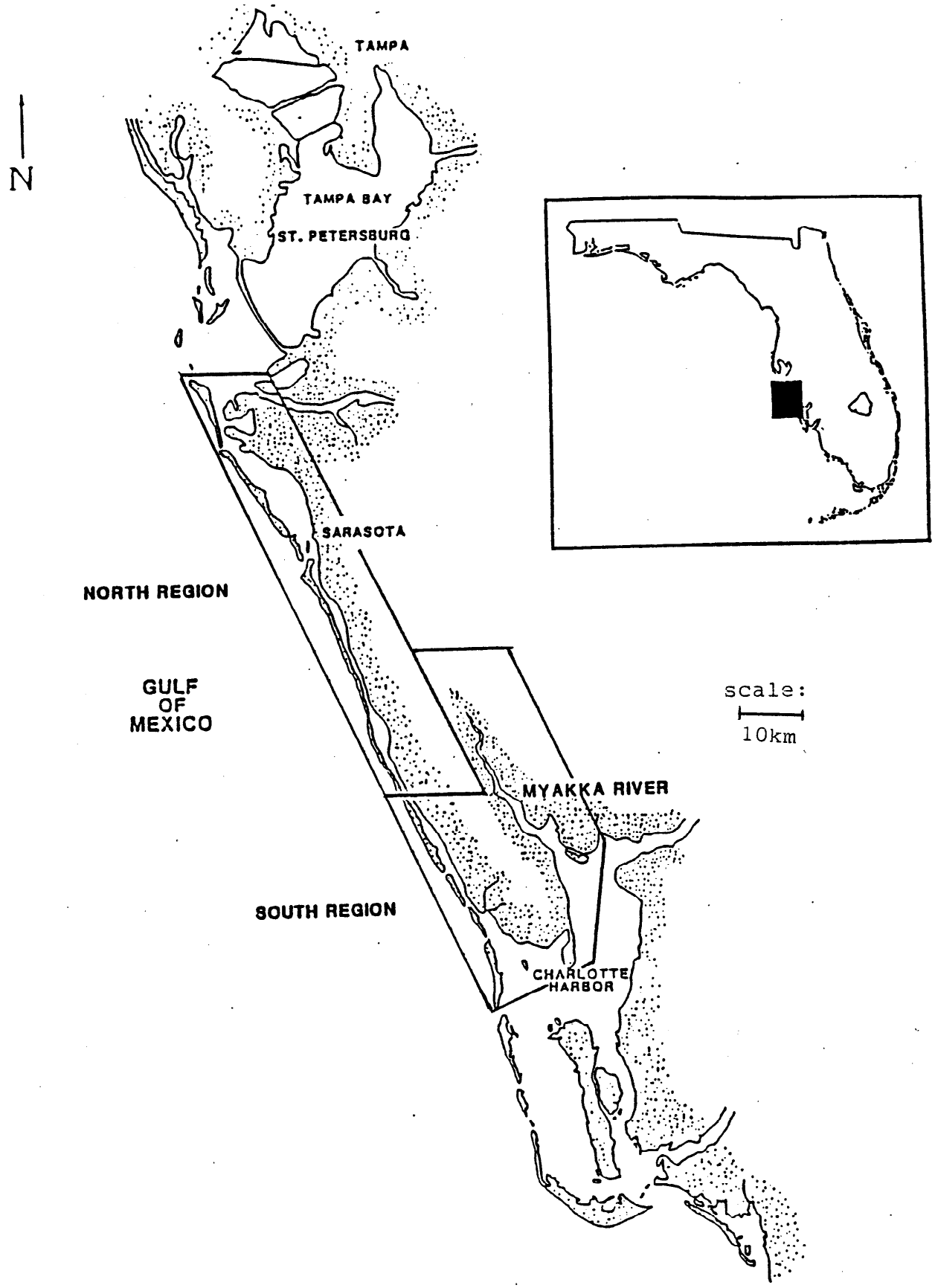


Figure 1. Location of the study area, showing divisions -into north and south regions.

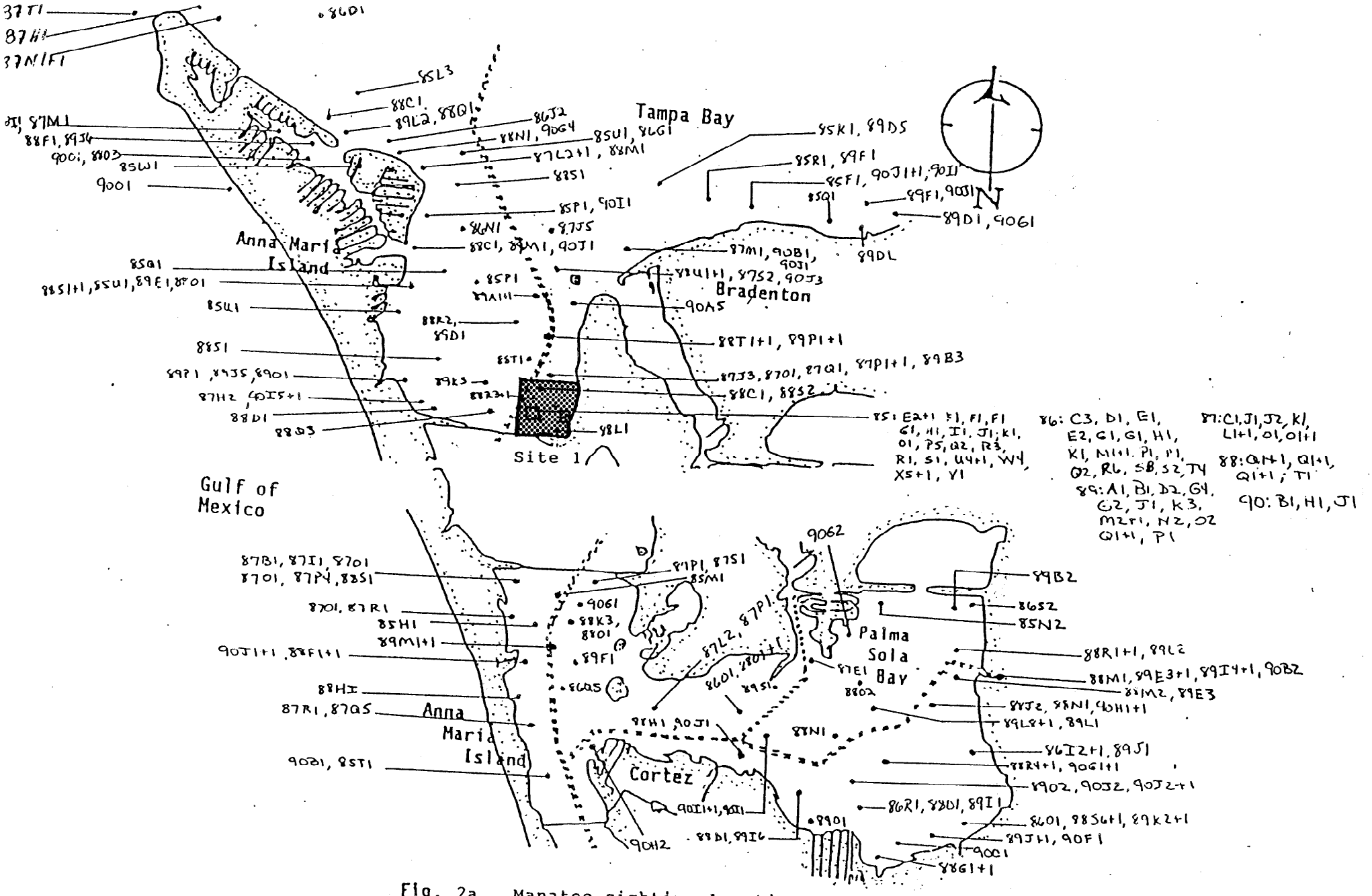


Fig. 2a. Manatee sighting locations, 1985-1990: Mouth of the Manatee River and Anna Maria Sound showing Site 1 (SE Corner Anna Maria Sound).

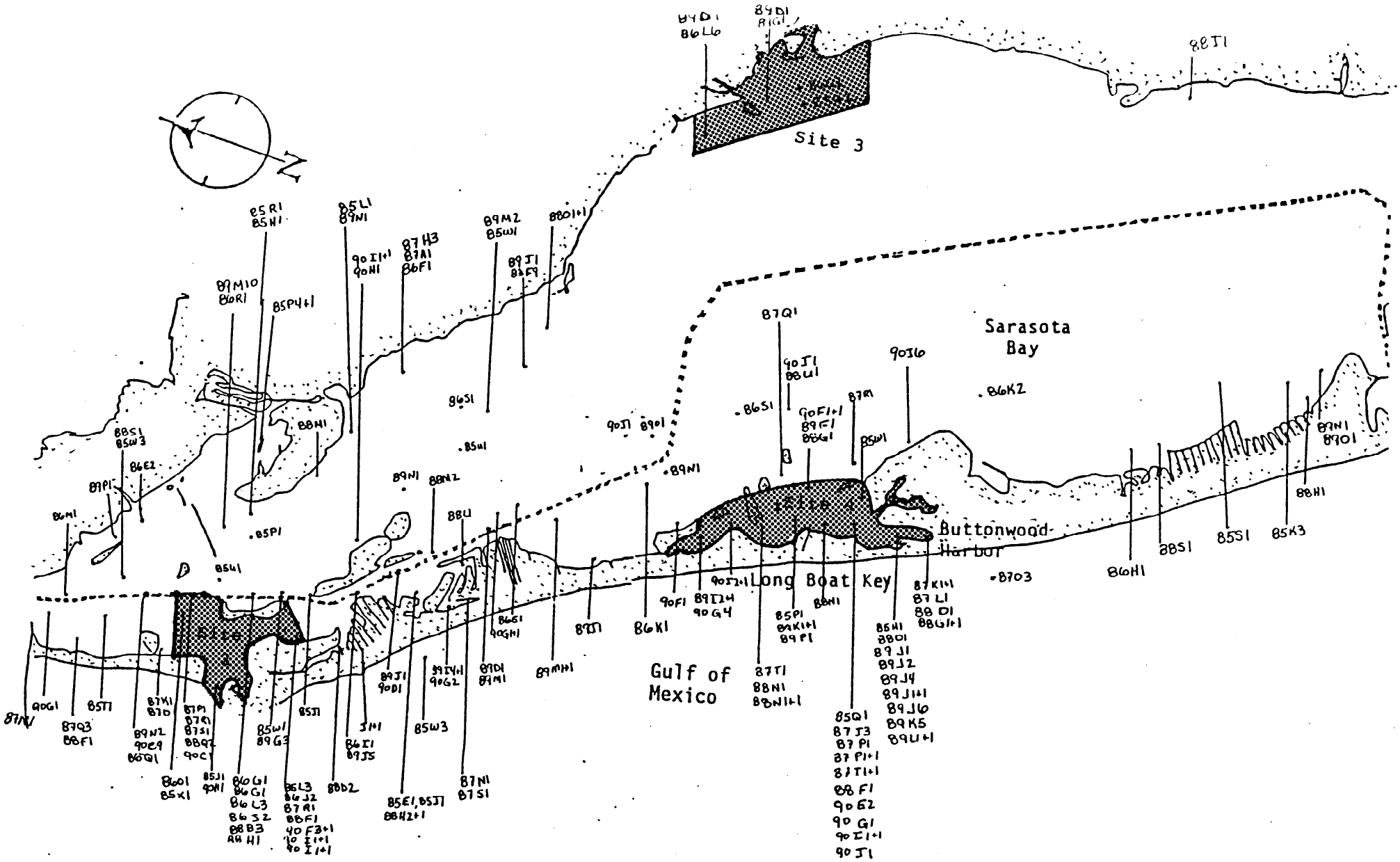


Fig. 2b. Manatee sighting locations, 1985-1990: Sarasota Bay showing Sites 2,3,&4 (Longboat Pass, Bowlees Creek, and Buttonwood Harbor respectively).

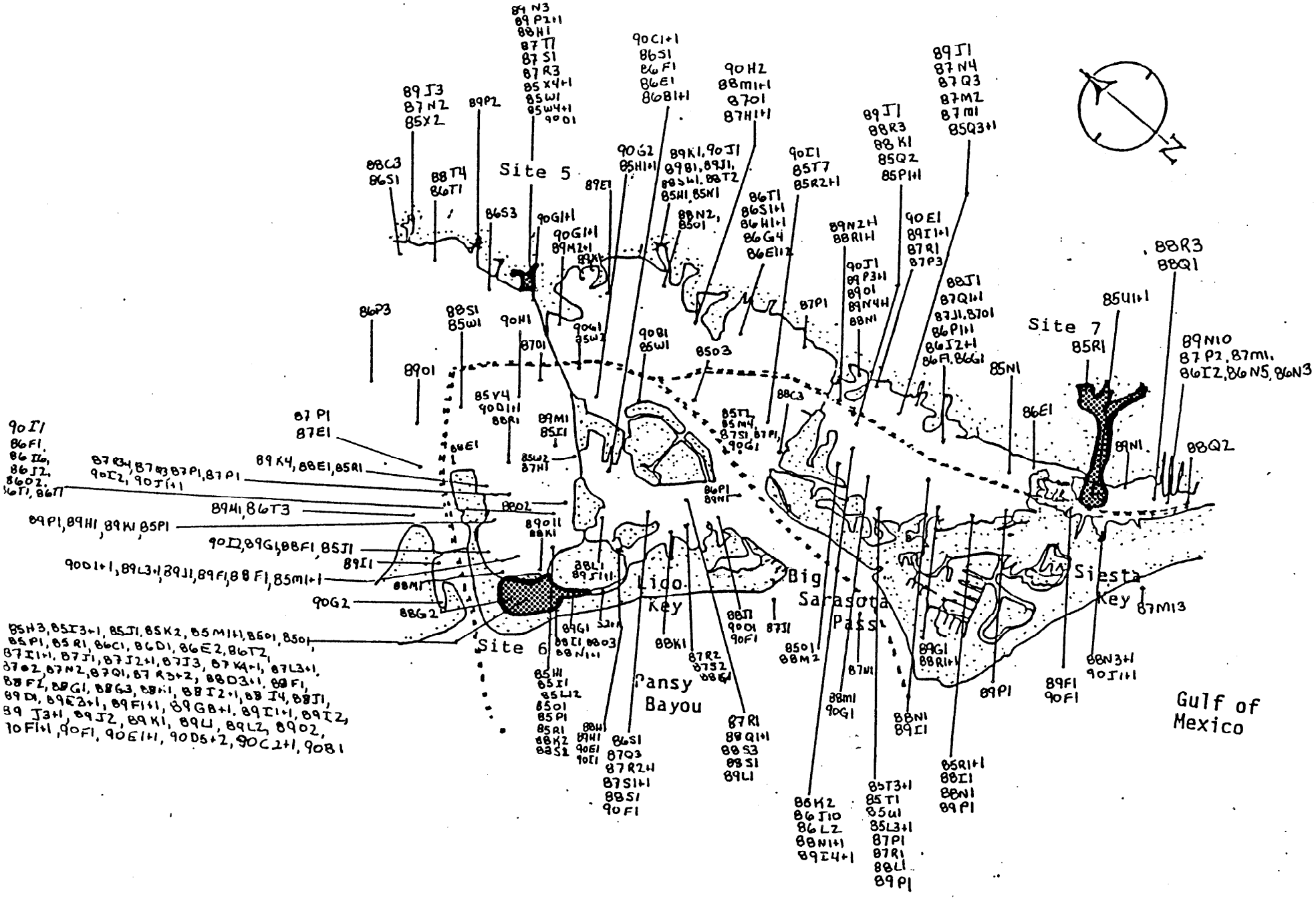


Fig. 2c. Manatee sighting locations, 1985-1990: Sarasota area showing Site 5,6&7 (Hyatt, Pansy Bayou and Phillippi Creek respectively).

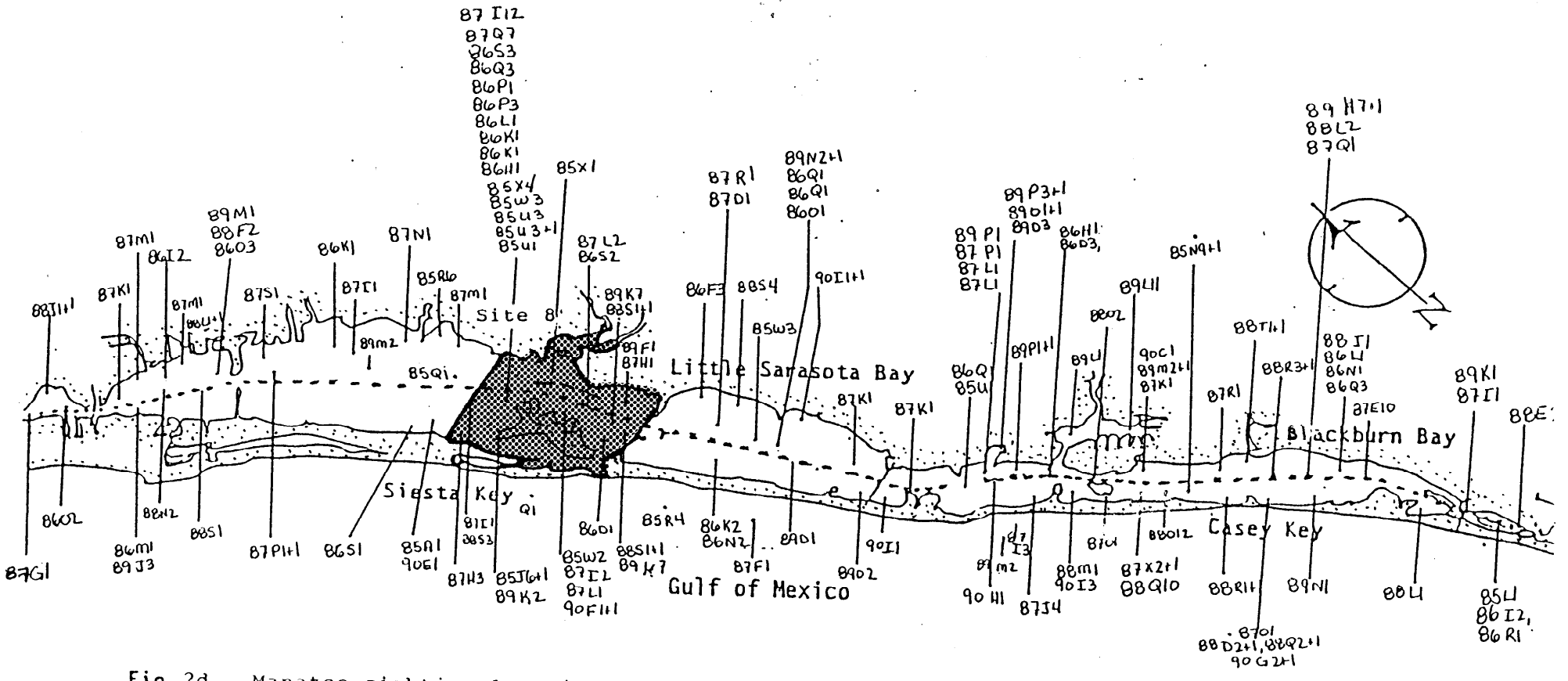


Fig. 2d. Manatee sighting locations, 1985-1990: Little Sarasota Bay and Blackburn Bay showing Site 8 (Midnight Pass).

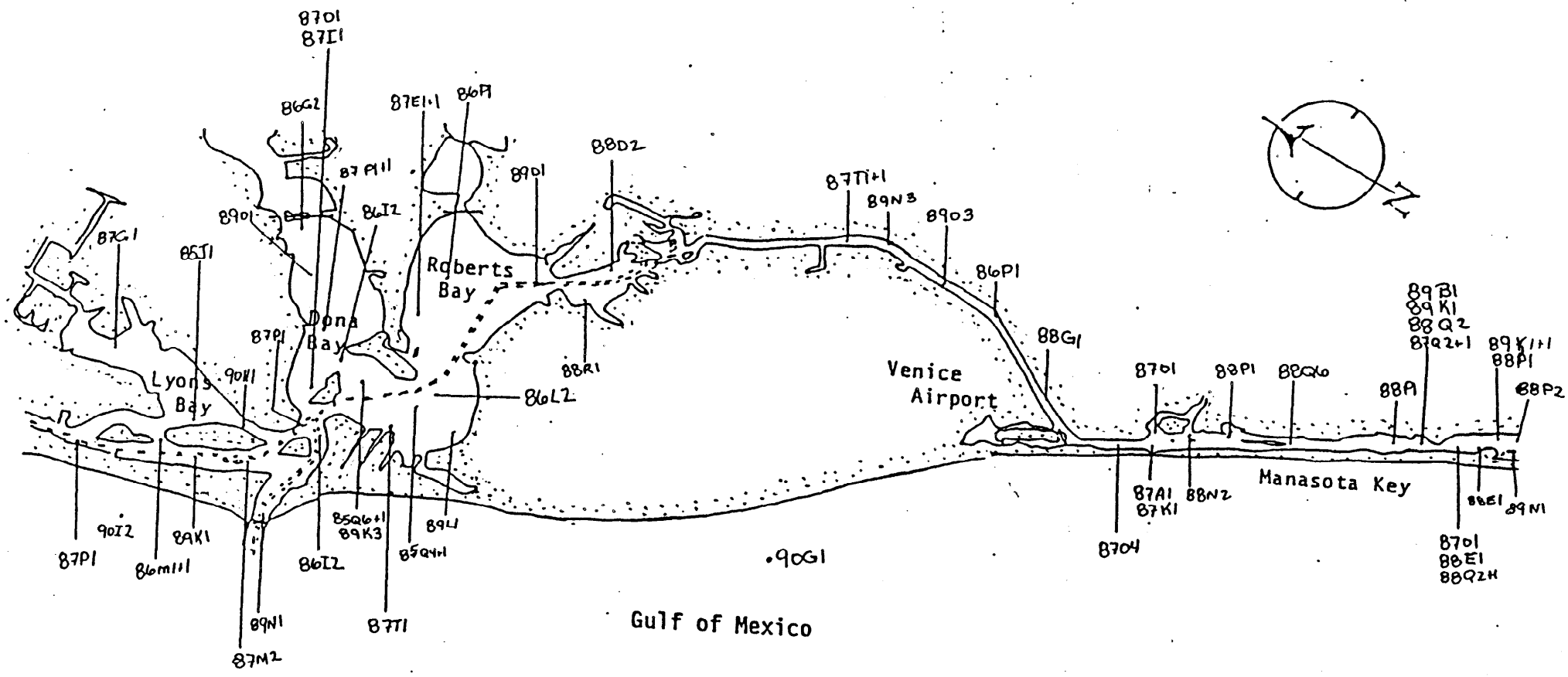


Fig. 2e. Manatee sighting locations, 1985-1990: Venice area.

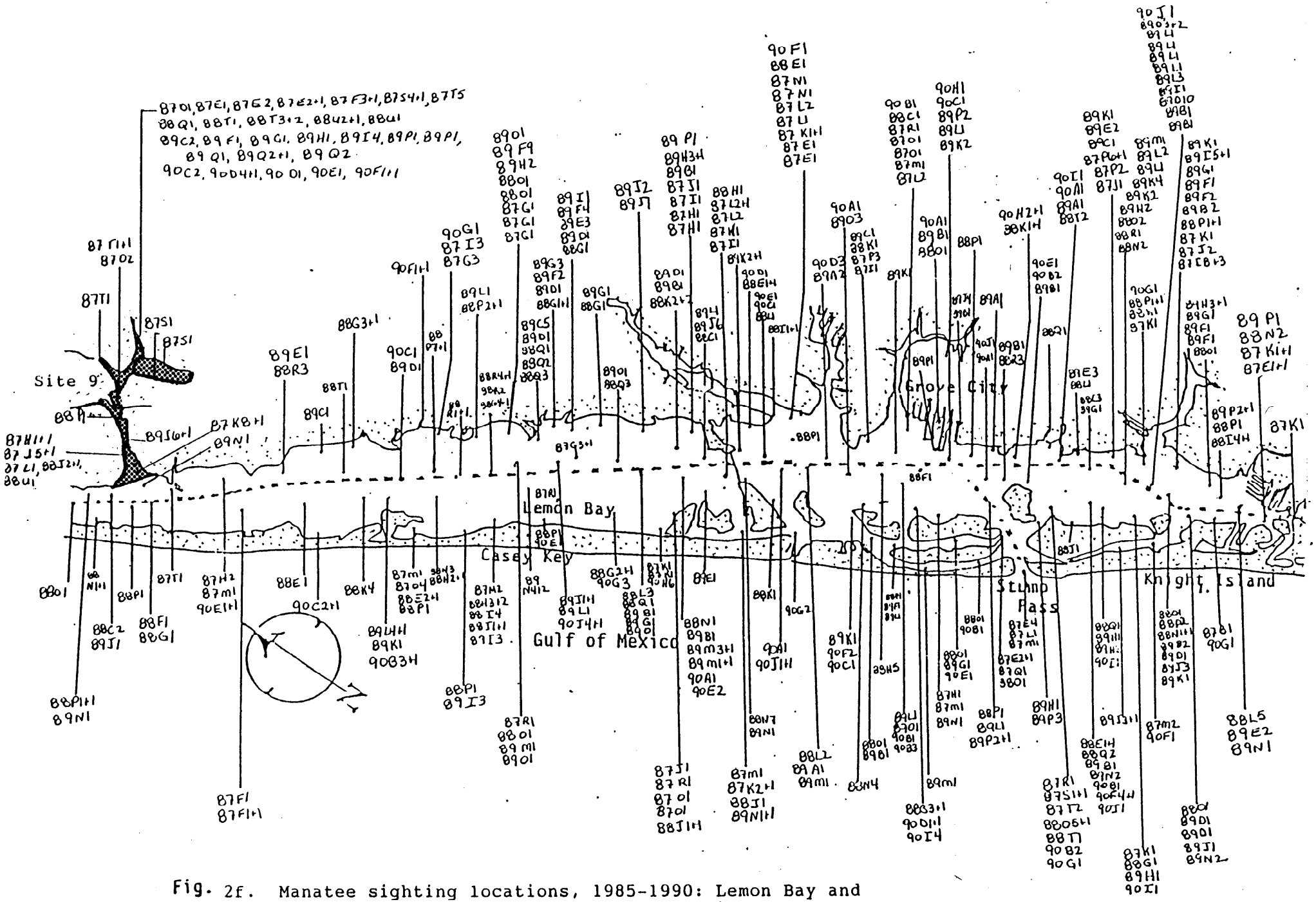
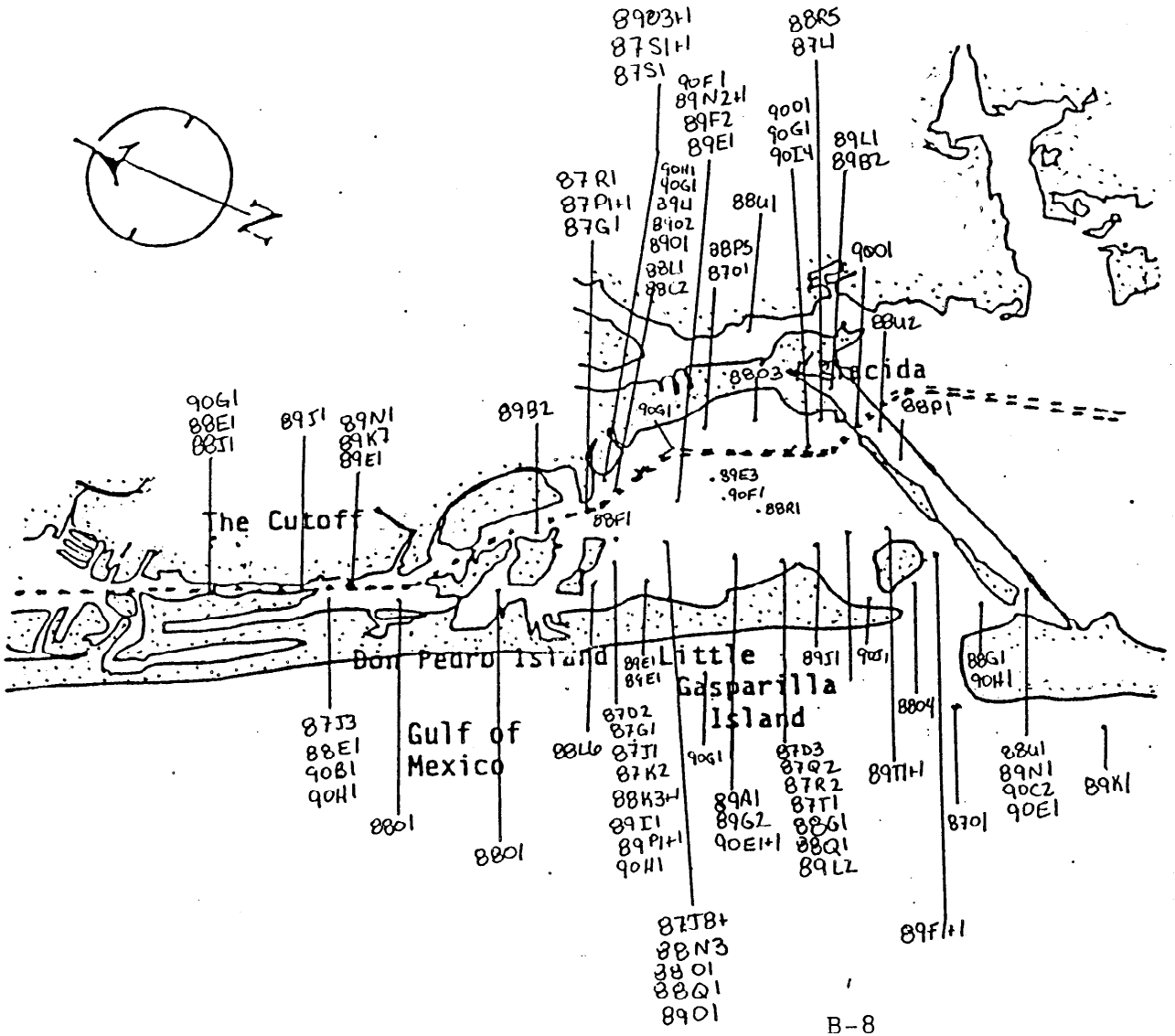


Fig. 2f. Manatee sighting locations, 1985-1990: Lemon Bay and Stump Pass showing Site 9 (Forked Creek).

Fig. 2g. Manatee sighting locations, 1985-1990: Placida Harbor.



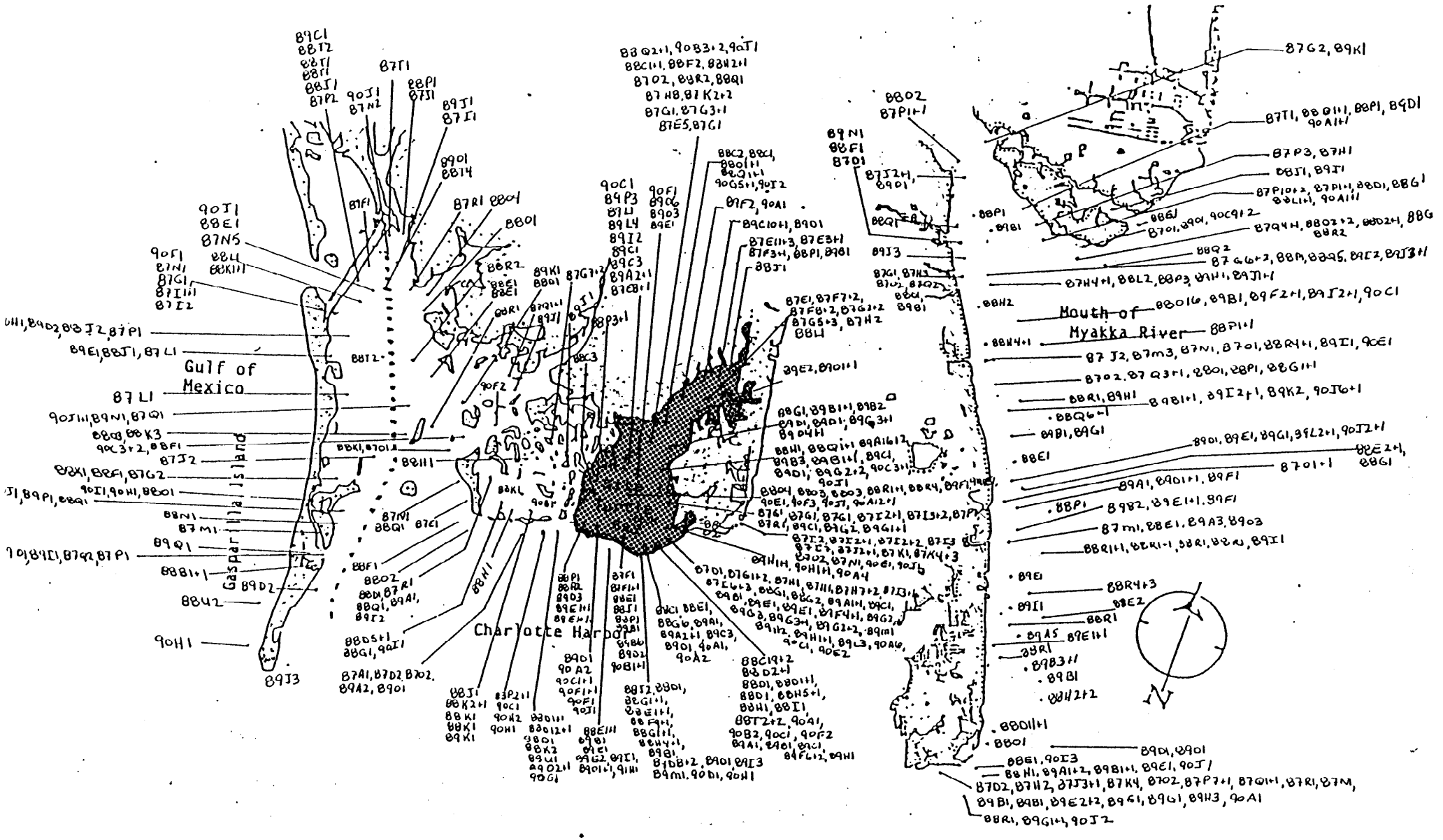


Fig. 2h. Manatee sighting locations, 1985-1990: Gasparilla Sound and northern Charlotte Harbor showing Site 10 (Turtle Bay).

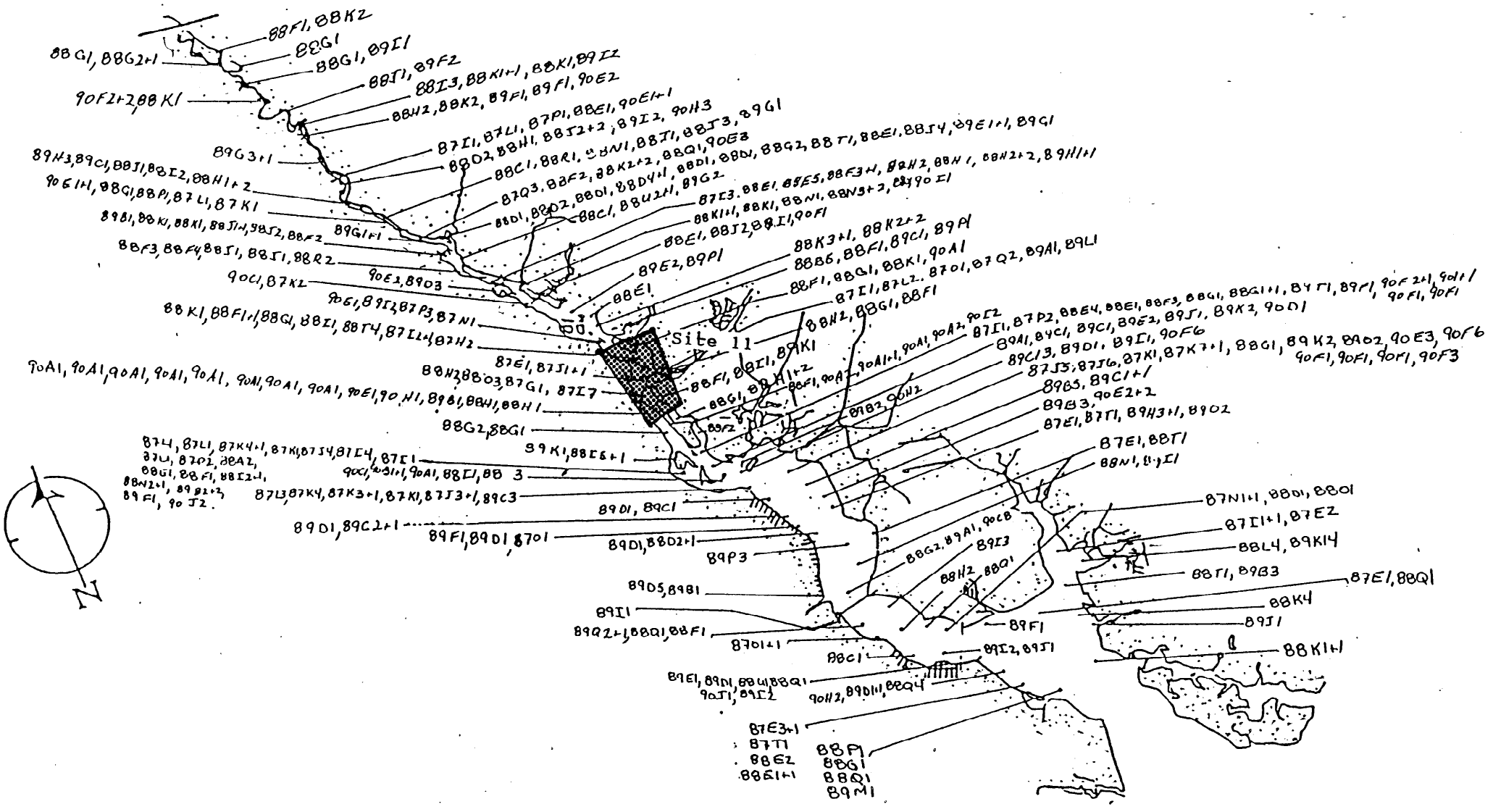


Fig. 2i. Manatee sighting locations, 1985-1990: Myakka River showing Site 11 (Big Slough).

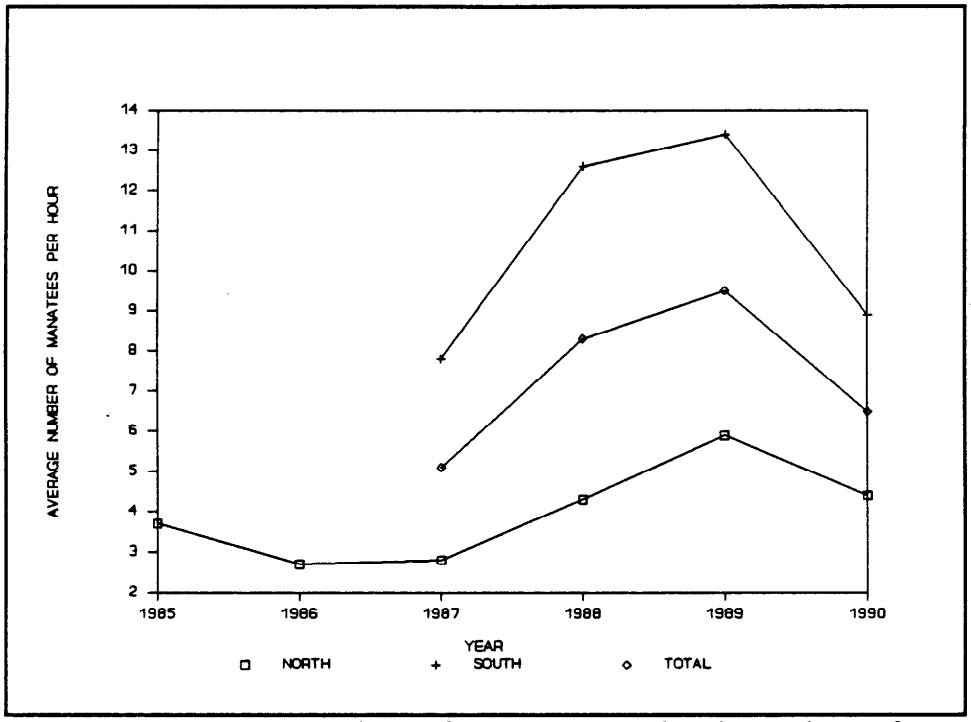


Figure 3. Average number of manatees sighted per hour for each year, 1985-1990, in the entire survey area.

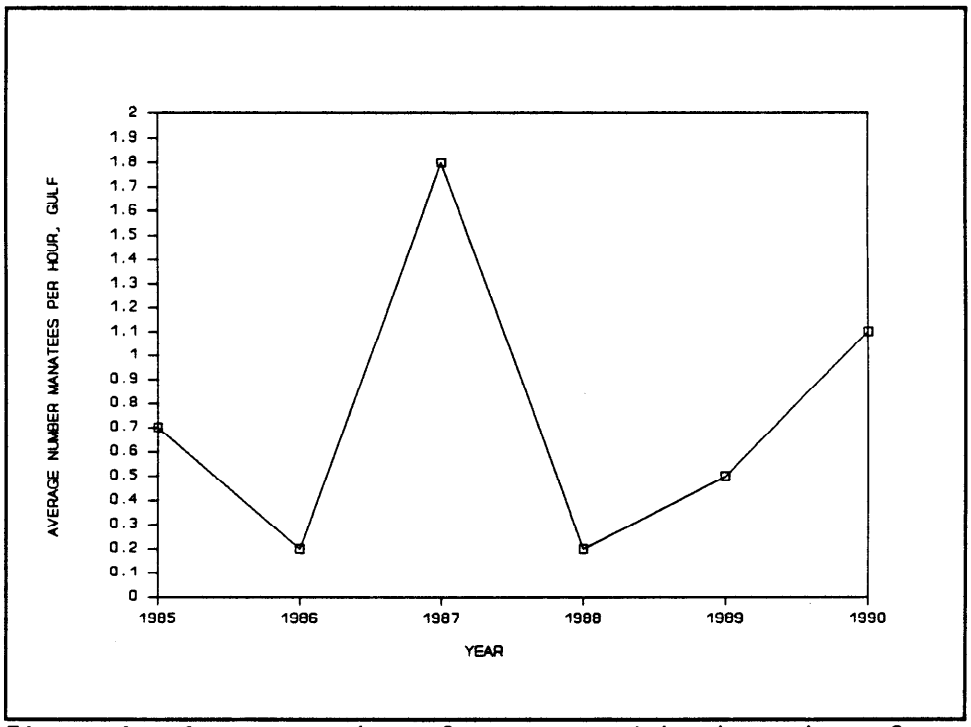


Figure 4. Average number of manatees sighted per hour for each year, 1985-1990, in the Gulf of Mexico (north and south combined).

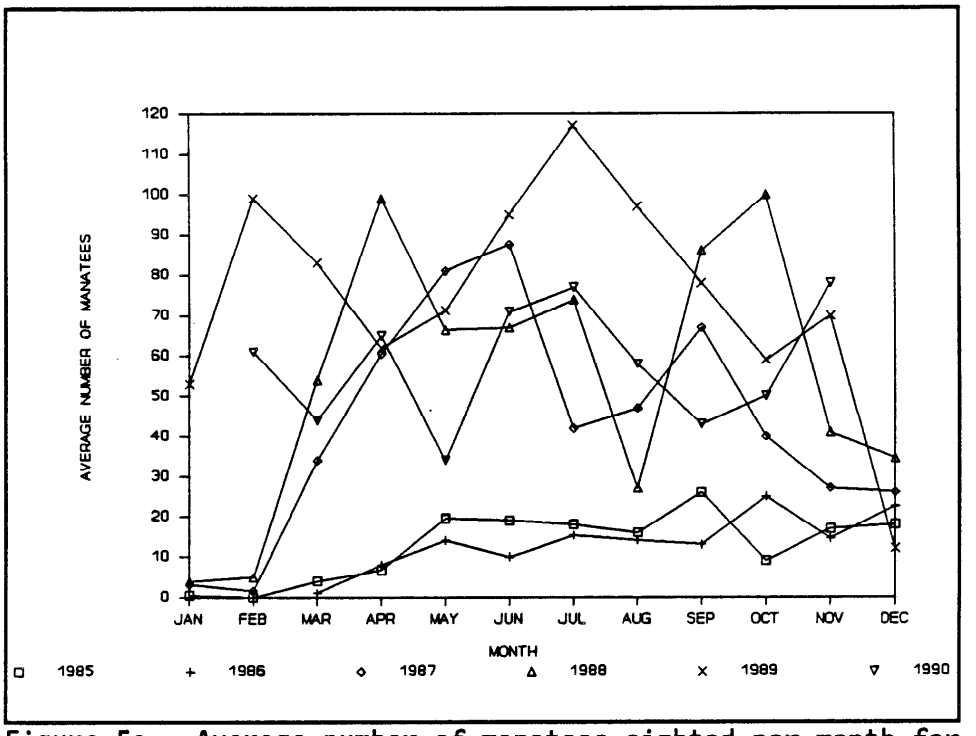


Figure 5a. Average number of manatees sighted per month for each year, 1985-1990.

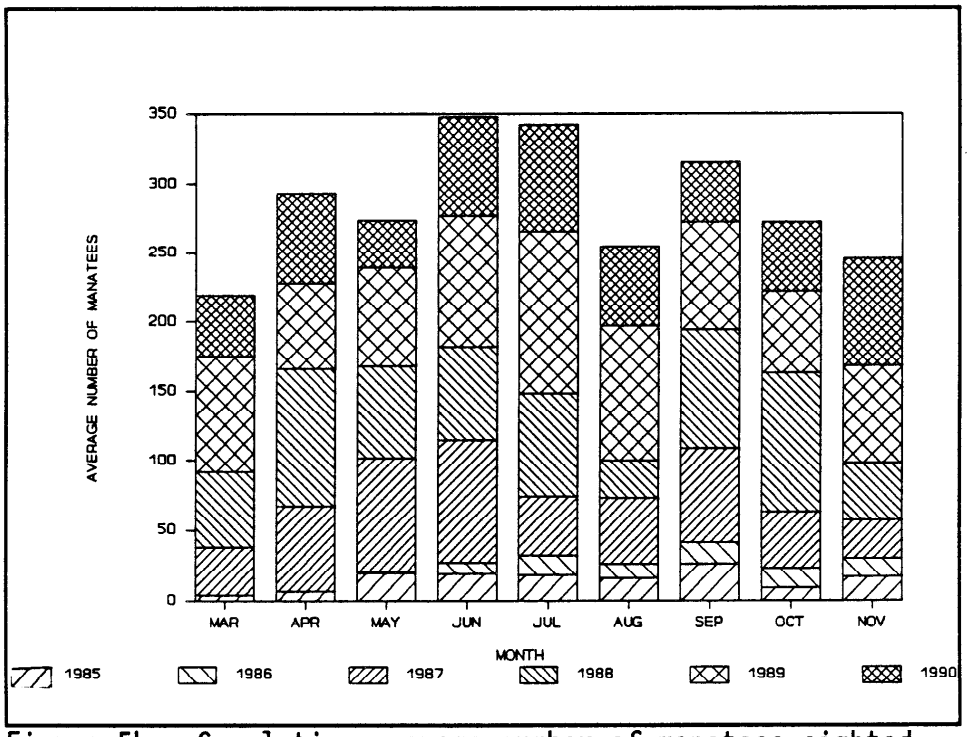


Figure 5b. Cumulative average number of manatees sighted per month (March to November) for all combined years, 1985-1990.

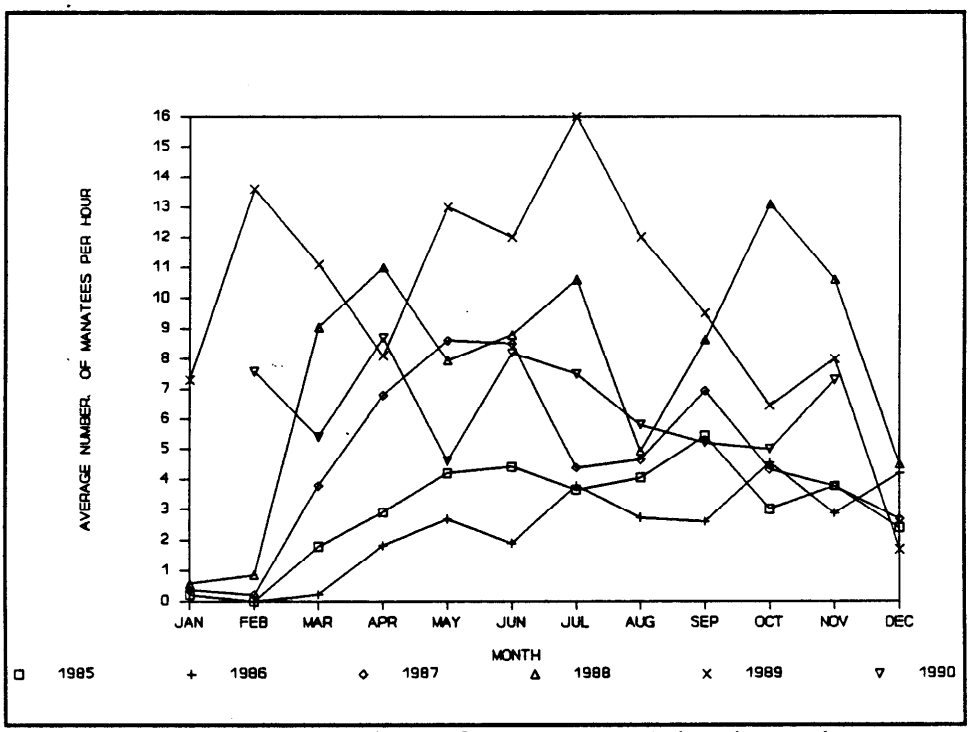


Figure 6a. Average number of manatees sighted per hour per month for each year, 1985-1990.

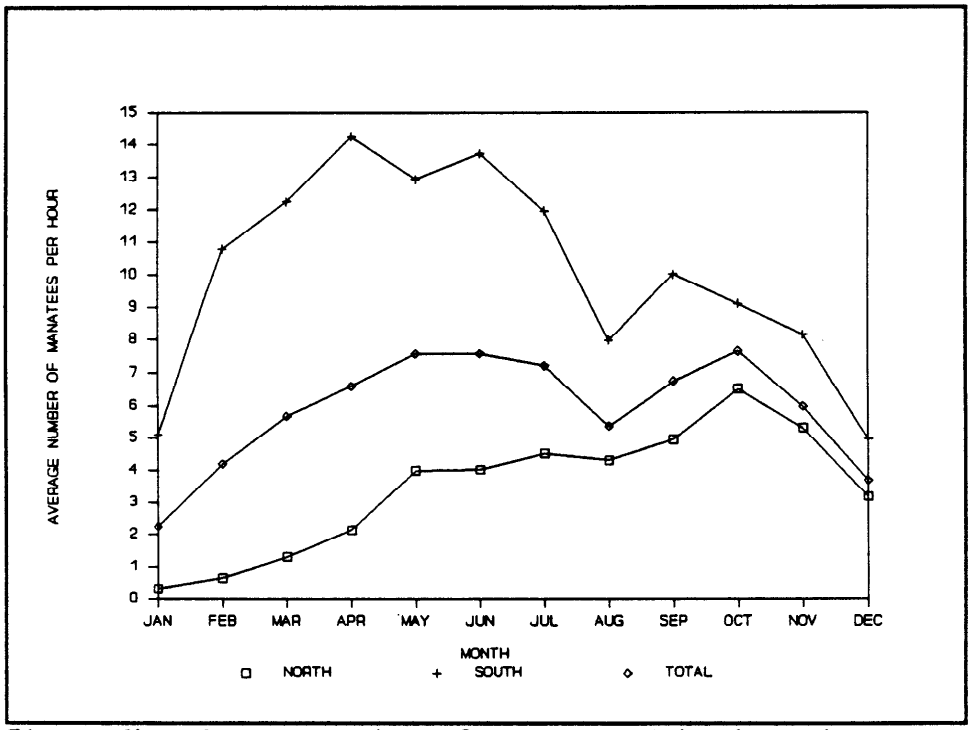


Figure 6b. Average number of manatees sighted per hour per month for all combined years, 1985-1990.

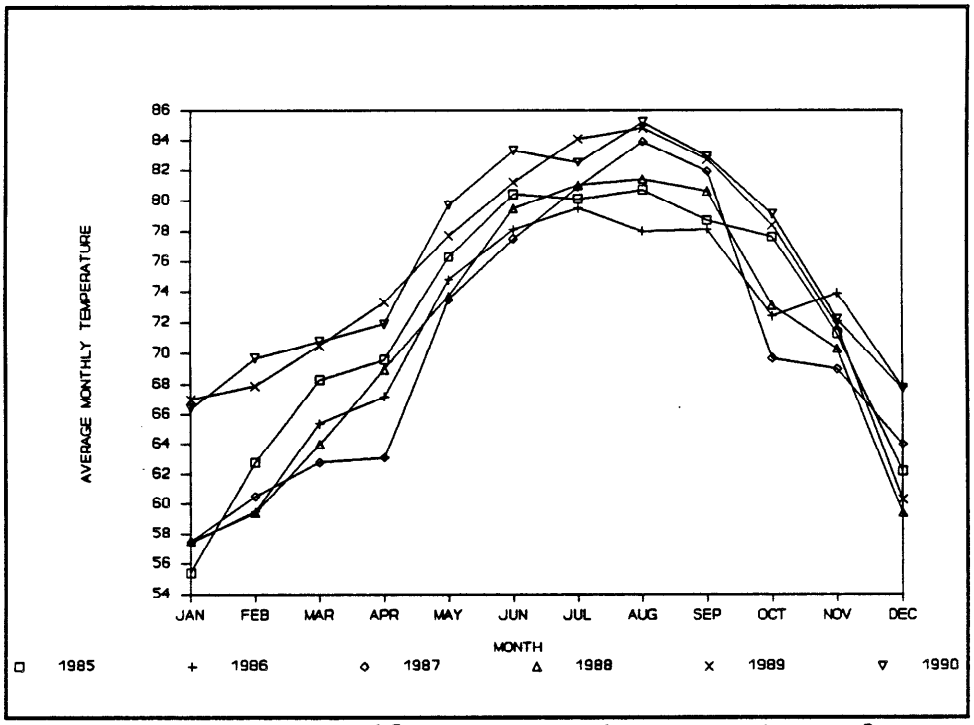


Figure 7. Average monthly Sarasota air temperatures for each year, 1985-1990.

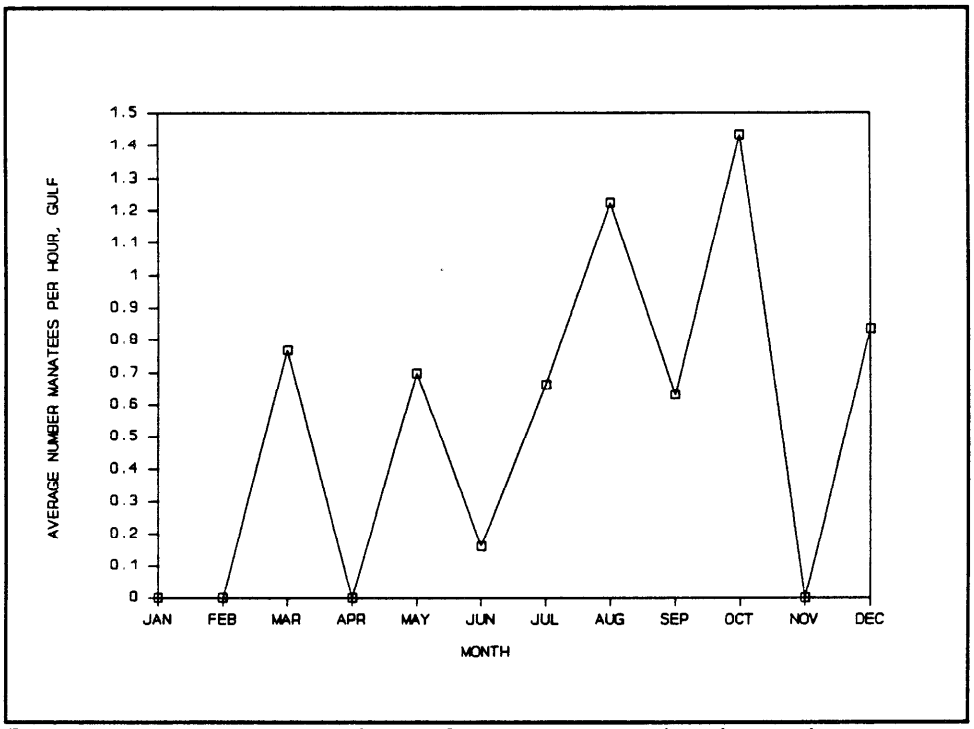


Figure 8. Average number of manatees sighted per hour per month for all years, 1985-1990, in the Gulf of Mexico (north and south combined).

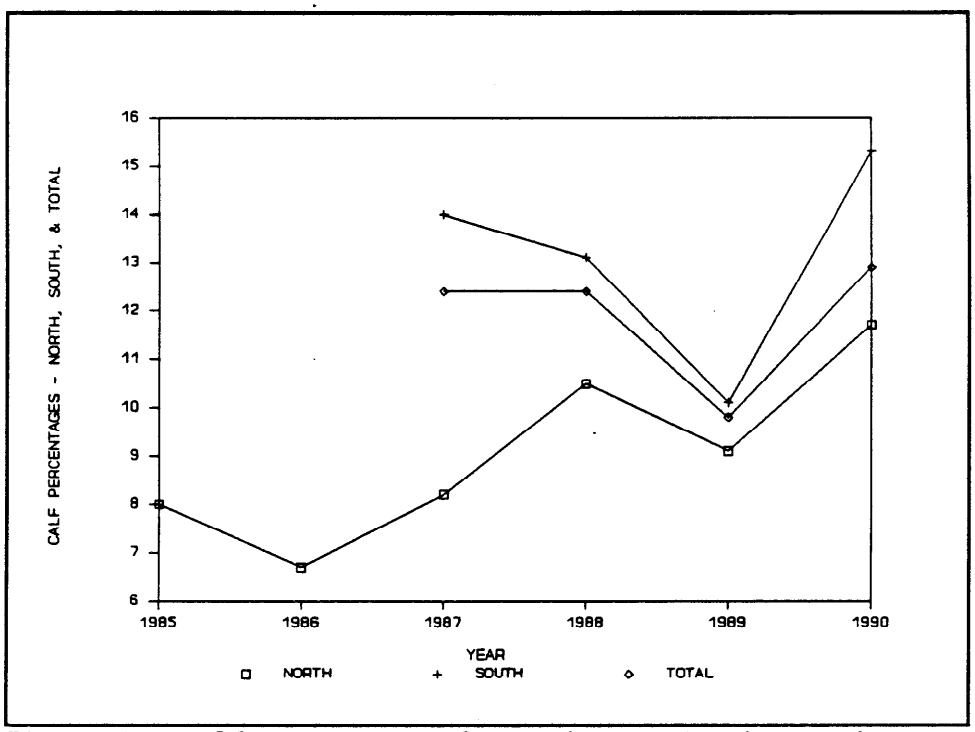


Figure 9. Calf percentages for each year in the north, south, and total survey region, 1985-1990.

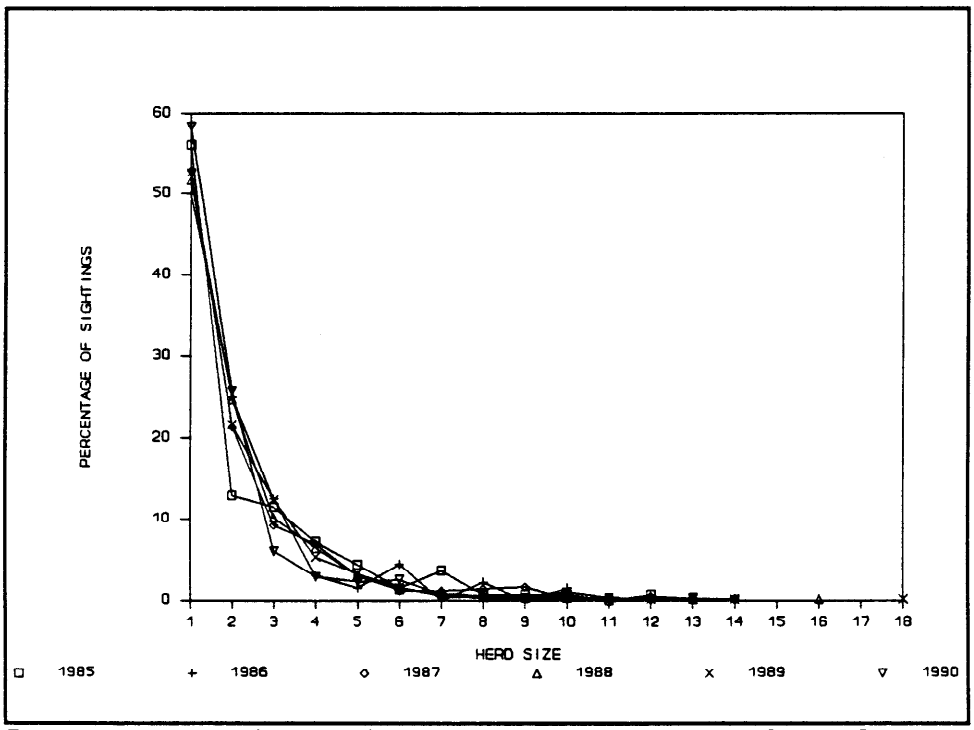


Figure 10. Herd size distribution as percent of total sightings for each year, 1985-1990.

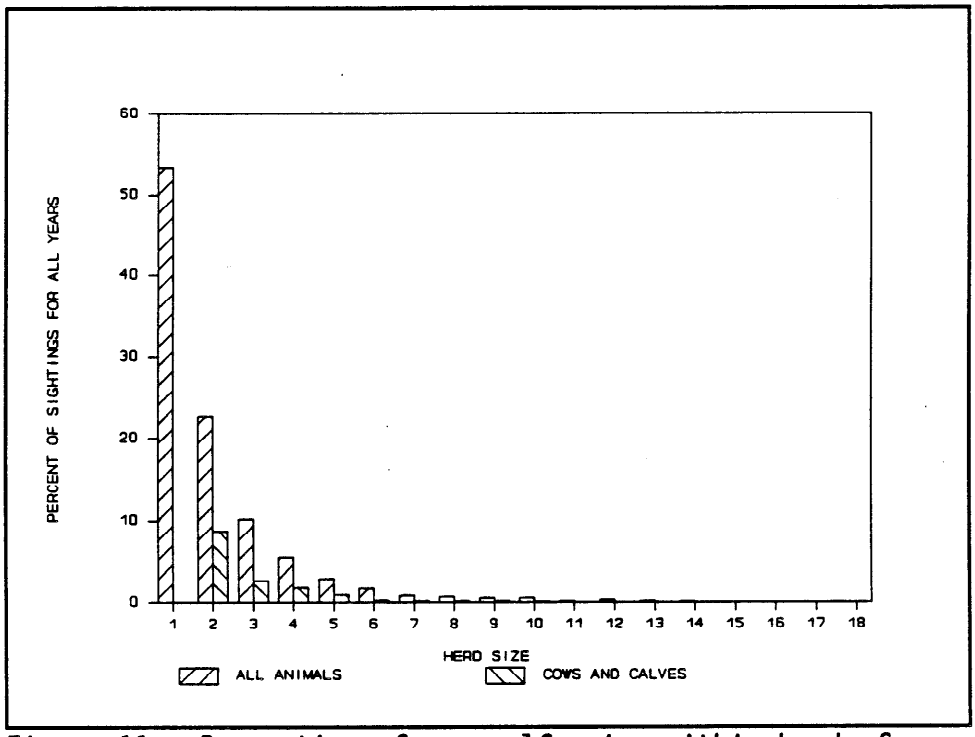


Figure 11. Proportion of cow-calf pairs within herds for all years, 1985-1990.

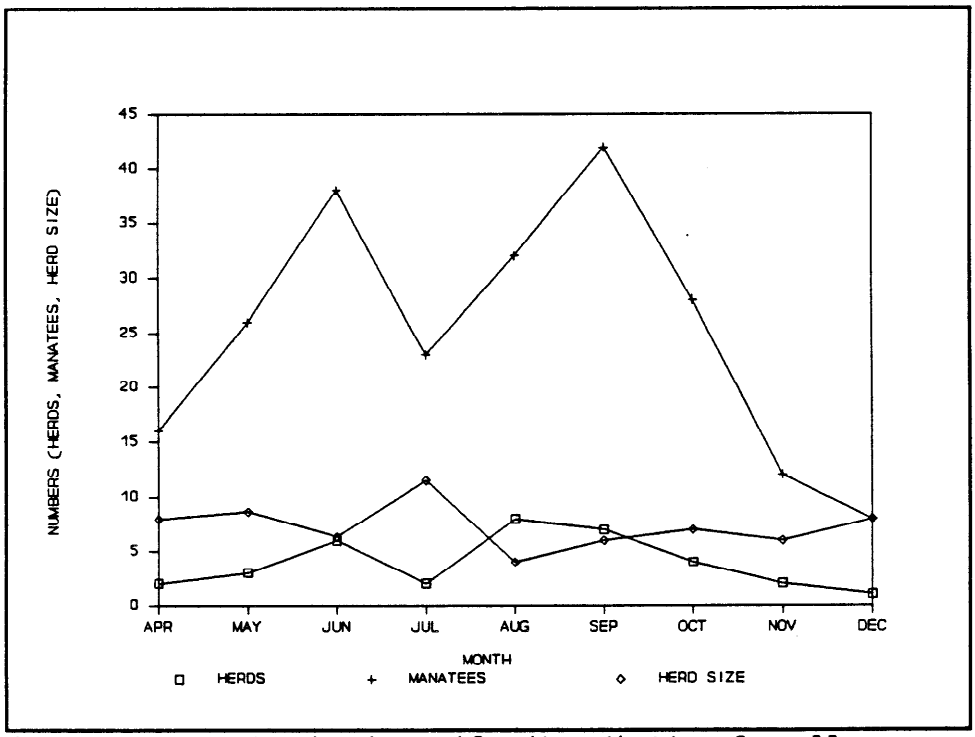


Figure 12. Mating herd monthly distribution for all years, 1985-1990.

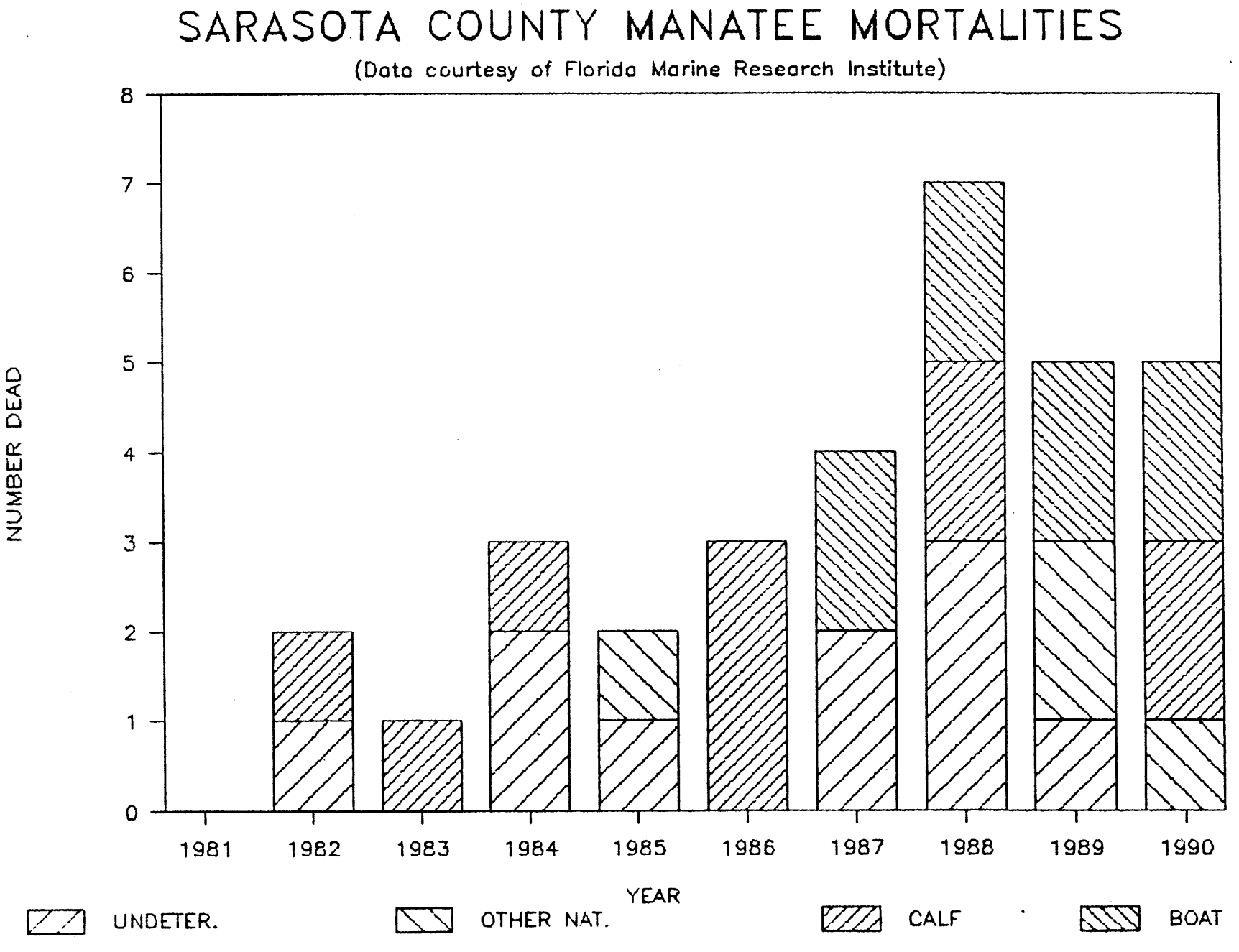


Figure 13. Manatee mortalities for Sarasota County, 1981-1990.